until they strike an object, when they solidify on contact. Thus bodies exposed to mist or fog at low temperatures become covered with a coating of light fluffy ice to which we give the name of 'rime'. In certain conditions of thin mist hoar frost and rime may both be formed at the same time.

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Empirical Factors in Weather Forecasting.

THE Meteorological Office always welcomes friendly and constructive criticism, and therefore it gives me much pleasure to reply to the points raised by Mr. Wilfred Trotter in his letter published in NATURE of Oct. 19. Mr. Trotter's main indictment is that modern British forecasts prepared on synoptic charts take too much account of the pressure systems shown on those charts and too little of that general tendency for persistence of weather which sometimes seems to cause fine weather to continue for a long unbroken spell with little regard to the pressure distribution. It would be idle to deny that there may be some truth in this charge, but perhaps I may point out some of the difficulties with which the forecaster is faced. Let us take as an example a case which was fairly common during last summer, when a trough of low pressure over Ireland, stretching down from an Icelandic depression, is moving eastward across the British Isles and probably already giving some rain in Ireland. The question to be answered is, Will this rain spread to the south and south-east of England? The forecaster knows from his experience that in normal circumstances it will generally do so. In the particular type of weather which we are discussing he also knows that the past month or past few months have been abnormally dry. There are these two conflicting elements to be balanced. If he leaves out rain and it comes, he fails in what to many people is the most important factor of his forecast. He decides that he cannot take this risk with no better grounds for the omission than the somewhat nebulous one that the summer has so far happened to be abnormally dry. He therefore indicates the probability of some rain; when he comes to the office the next day and reviews the situation, he may wish that he had taken the risk and left out the reference to rain. It is easy to be wise after the event. It must be remembered that, even in a dry summer like the past, there have been days when troughs of low pressure have given rain in the south of England, so that if the forecaster had omitted to mention it on every occasion, he would in some cases have been wrong, and badly wrong.

There is a further point. The Meteorological Office has to forecast for the whole of the British Isles, and it frequently happens that drought in one part of the country coincides with excessive rain in another part. We have been taken to task already this summer for not making enough mention of heavy rains which fell in the West Highlands of Scotland. The forecaster, therefore, who is looking at the whole of the country may not have the dryness of the season impressed upon him quite so strongly as members of the public who see the weather in their own locality only, and from the nature of the case take little account of that in other areas. We have been aware of this tendency to forecast rain more frequently than the event proves to be necessary in dry spells for many years, and if we have failed to benefit by experience, this is due more to the difficulty which I have tried to indicate above than to ignorance of the facts. The cure will be found in more science, not less. When we really understand the workings of the atmosphere and have enough upper air observations to tell us what is happening at the time, we shall know that the particular trough which is approaching cannot bring rain; but that time has not arrived yet.

One further criticism is made by Mr. Trotter, and that is with regard to the forecasting of summer thunderstorms, his charge being that too little account is taken of the time of year and that thunderstorms are forecast as confidently in the latter part of August, or even in September, as in the middle of July when the thunderstorm season is at its height. The forecasting of thunderstorms is perhaps the branch into which more scientific method has been introduced than into any other branch of forecasting, and much account is now taken of whether the upper air conditions, as shown by aeroplane ascents, are stable or unstable. Nevertheless, these observations are not always available when required, and then the older methods of forecasting by pressure distribution and surface temperature have to be used exclusively.

I have not statistics available to show whether Mr. Trotter is right in thinking that the trustworthiness of the forecasts of thunder declines steadily throughout August. The average number of days of thunder at Kew Observatory in August is equal to that in July, and higher than in any other month of the year, though the September figures show a sharp drop. Recent criticisms of our forecasts have suggested that we forecast thunder too often throughout the whole summer, and I believe that this is largely due to the fact that any individual observer is concerned only with the thunder in his immediate vicinity, whereas our forecasts cover a whole district. If a thunderstorm is likely in any part of that district, we do not feel justified in omitting it from the forecast. The number of days in an average summer when thunder is reported at a few isolated places but by no means generally over a district, is very considerable.

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The Motion of a Lorentz Electron as a Wave Phenomenon.

I HAVE been able to express the equation representing the uniform motion of the surface of a Lorentz electron in a form which strongly suggests that the 'parcel' or particle aspect of the phenomenon may be associated with the interference of two waves. Thus, if (x, y, z) are Cartesian co-ordinates relative to a material observer and t is his proper time, the motion of the electron's surface is represented by

$$\frac{(lx+my+nz-c\beta t)^2}{1-\beta^2}+(\lambda x+\mu y+\nu z)^2+(Lx+My+Nz)^2=a^2,$$

where (l, m, n) are the direction cosines of the velocity $c\beta$ and a is the rest radius. On account of relations of the types

$$l^2+\lambda^2+L^2=1,$$
$$lm+\lambda\mu+LM=0,$$

this is reducible to

$$\phi(x, y, z, t)=a^2, \quad . \quad . \quad . \quad (1)$$

where

$$\phi(x, y, z, t)\equiv\psi(x, y, z, t)+\frac{1}{m_0{}^2c^2}\{W(x, y, z, t)\}^2, \quad (2)$$

$$\psi(x, y, z, t)\equiv x^2+y^2+z^2-c^2t^2, \quad . \quad . \quad (3)$$

$$W(x, y, z, t)\equiv\frac{m_0c\beta}{\sqrt{1-\beta^2}}\left(lx+my+nz-\frac{ct}{\beta}\right) \quad . \quad (4)$$

(m_0 is the rest mass of the electron). The function ψ

represents a Maxwellian wave surface travelling with the fundamental velocity c, and the function W is the action function and consequently represents a de Broglie-Schrödinger wave surface travelling with the velocity c/β. Relative to an observer travelling with the velocity c, the Maxwellian function ψ disappears from W, and the Schrödinger wave surface coincides with the surface of the electron, both in fact reducing to a plane Maxwellian wave surface

$$l_1x_1 + m_1y_1 + n_1z_1 + ct_1 = 0, \qquad (5)$$

where the suffix 1 relates to the new observer. This suggests that our electrons would appear from a ray of light as rays of light, and a similar argument may show that our rays of light would appear as electrons. This reciprocal relation between matter and radiation involving a dual aspect of each, if accepted as a principle, may help to elucidate problems of interaction between these two fundamental entities of physical science. Fuller details will be published later.

A. M. MOSHARRAFA.

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Cairo, Sept. 19.

Magnetic Reaction of Carbon Filaments.

AN ordinary magnet, or a current carrying winding adjacent to the filament of a carbon filament lamp, produces the oscillation shown in the accompanying photograph (Fig. 1) when the filament is glowed, the effect commencing at the dark heat radiation point and increasing with increasing filament radiation.

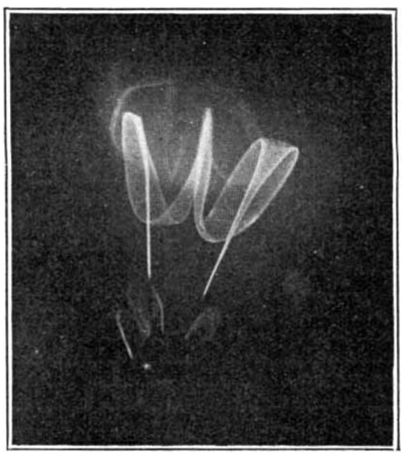

FIG. 1.

When filament and winding currents are both direct, simple distortion occurs. The cold filament placed in actual contact with a magnet shows no affinity thereto.

It thus appears that, when radiating, the carbon filament assumes magnetic properties which may be due to

(1) Decrease of inertia of the filament;
(2) Atomic rearrangement;
(3) Impurities in the filament.

Regarding the last, some filaments have been produced from a colloidal zinc salt.

As a matter of interest, tungsten and tantalum filaments gave no magnetic reaction, though it should be said that these filaments are more rigidly supported than the carbon type.

The best results are obtained with a carbon filament lamp having large and few filament coils, for example a 150-volt size.

Using a horseshoe magnet, positions of maximum magnetic disturbance will be found when the poles are in the planes of the coil axes, the effect decreasing gradually towards the mid-points.

CEDRIC W. MARSHALL.

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Leeds.

Rearing Experiments with Starfish and Obstetric Toads.

PERHAPS readers of NATURE would be interested to hear the results of two rearing experiments which were carried out under my supervision this summer by two of my pupils in the Zoological Laboratory of the Imperial College of Science.

(1) The common starfish, *Astenas rubens*, was obtained from Plymouth. The eggs were artificially fertilised and the larvæ were reared through their entire development, until they metamorphosed into young starfish—a process which occupied $2\frac{1}{2}$ months. This feat had been accomplished in Plymouth and in Millport, but this is the first time that it has been done with eggs which travelled 226 miles from the sea. The development and beating of the larval heart were studied. Mr. Murtri, the pupil who carried out the experiment, also studied the development and beating of the larval heart of *Echinus miliaris*—a species which we rear in our aquaria through its entire development every year. The heart of *Echinus* beats almost four times as fast as that of *Asterias*.

(2) Through the kindness of Mr. E. Boulenger, director of the Aquarium of the Zoological Society, a consignment of thirty specimens of *Alytes obstetricans* were obtained from Germany. These were entrusted to the care of my pupil Miss Sladden, who has great skill in rearing Amphibia. Eighteen of the specimens were removed to our greenhouse, in which a temperature of from 80° to 85° F. was maintained to see if they would become acclimatised, but almost all of them died within a few weeks. The remaining 12, including two males carrying eggs, were kept under approximately natural conditions and all survived. Each of the two males carried from 30 to 40 eggs; from each batch 20 tadpoles hatched out. Of these 40 tadpoles, no less than 38 were successfully reared through the metamorphoses. After metamorphosis 18 of the young toads were transferred to the greenhouse, 10 were transferred to an out-of-doors vivarium, and 10 to an indoors vivarium. The little toads are now two months old, and only one has died—that one being amongst those subjected to warmth.

Thus Kammerer's statements that *Alytes* could become acclimatised to a high temperature and that in these circumstances it would revert to a water-inhabiting life have been confirmed. Whether we shall have the skill, resources, and time to rear further generations of *Alytes* is still on the "knees of the gods". E. W. MACBRIDE.

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Age of the Tahitian Coral Reefs.

DR. CYRIL CROSSLAND (NATURE, Oct. 12, p. 576) refers to my discovery of coral fragments in a parasitic tuff-cone at Tataa Point, at the north-west corner of Tahiti. The size and water-worn character of these fragments and of the associated basaltic pebbles in the tuff suggest that the cone was built by eruptions through an old beach sprinkled with coral debris. Had the eruption burst through a solid reef, it may reasonably be supposed that large angular blocks of